



## **The Carboniferous of East Thailand — new information from microfossils**

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**Abstract:** In 1996 for the first time, Carboniferous microfossils were discovered in east Thailand, at a single limestone locality. In 1997, another locality of the same area yielded Early Carboniferous corals. Because of these two discoveries, a systematic search for microfossils has been carried out in all the limestone exposures of that area. Microfossils have been found almost everywhere; they are rare to common. The fossils and the facies focus on an age ranging from Late Visean to Bashkirian.

The Carboniferous sediments of East Thailand were not documented in the past. Their presence had been suggested by a few bryozoans found in shale (Nakinbodee *et al.*, 1976). They consist of shale, silicified shale, siltstone, limestone, subordinate sandstone and conglomerate. In 1996, a first discovery of microfossils in the limestone of Khao Kradat (Fontaine *et al.*, 1996), then of corals in a limestone exposure east of Khao Yai Mo Noi (Fontaine and Salyapongse, 1997) suggested that the distribution of Carboniferous limestone should be relatively extensive, especially because limestone bodies reaching thicknesses of 10 to 100 meters are scattered in the area. As a matter of fact, these limestone exposures contain locally fossils in abundance; microfossils have been found at several localities and are the subject of this paper.

The sediments which have yielded the Carboniferous fossils crop out about 70 km east of Chonburi. Exposures are scattered in an area of about two hundred square kilometers, but they occupy only a small part of that surface. They are distributed in two land strips arranged in a northerly direction, about 2 km wide, parallel, discontinuous, 8 to 10 km far apart from each other. They are represented by small hills, with the exception of Khao Yai which is very large and reaches 777 m in elevation above sea level.

### **GEOLOGICAL SETTING**

To the east and to the south of the Carboniferous exposures, Mesozoic rocks are widespread and limestone has yielded Triassic foraminifera at Khao Cha-ang On (Fontaine, 1981; Vachard and Fontaine, 1988) and at Khao Tham Rat (Fontaine *et al.*, 1996); see Figure 1. Volcanic rocks are present in a large part of Khao Yai and extend to the northeast. They have been considered Permo-Triassic in age. Red beds are also locally prominent in adjacent areas. They were assigned to the Carboniferous in the past (Nakinbodee *et al.*, 1976). They have not yielded fossils yet, but they contain pebbles of volcanic rocks similar to the Permo-Triassic ones. They actually appear to be a unit of the Mesozoic.

To the west, thinly bedded sediments are

exposed in low hills and display a facies a little different from the Carboniferous rocks; they have been considered probably Silurian-Devonian in age without strong evidence. They consist of "phyllitic quartz conglomerate, quartzitic phyllite, carbonaceous phyllite, metasandstone, metatuffaceous sandstone, metasiltstone and slate. The Silurian-Devonian rocks appear to be transitional to the Carboniferous sandstone-shale-chert-limestone" (Salyapongse *et al.*, 1997). Farther to the west, metamorphic rocks are exposed and their relationship with the other sediments has not been deciphered so far.

Quaternary sediments are widespread in the studied area and they largely conceal the older rocks. To the north, they even form a large plain without outcrops of older rocks. They do not facilitate the research on the Carboniferous.

## THE CARBONIFEROUS SEDIMENTS

These sediments consist of shale, silicified shale, chert, limestone, sandy limestone, siltstone and minor sandstone. They build up a unit which is apparently about 1,000 m thick. They are strongly folded with dips commonly superior to 60°; their strike is approximately N30°W. Shale is the most prominent rock; it is exposed in low hills and is commonly highly weathered. It had yielded bryozoans with Fenestellidae which were considered Early Carboniferous in age, and very rare brachiopods (Nakinbodee *et al.*, 1976). Limestone is represented by small to large exposures; it builds up a few small hills. It is apparently restricted to a relatively thick horizon. It contains diverse fossils which are not distributed uniformly; see the following paragraph. Chert is rare in the area studied in this paper.

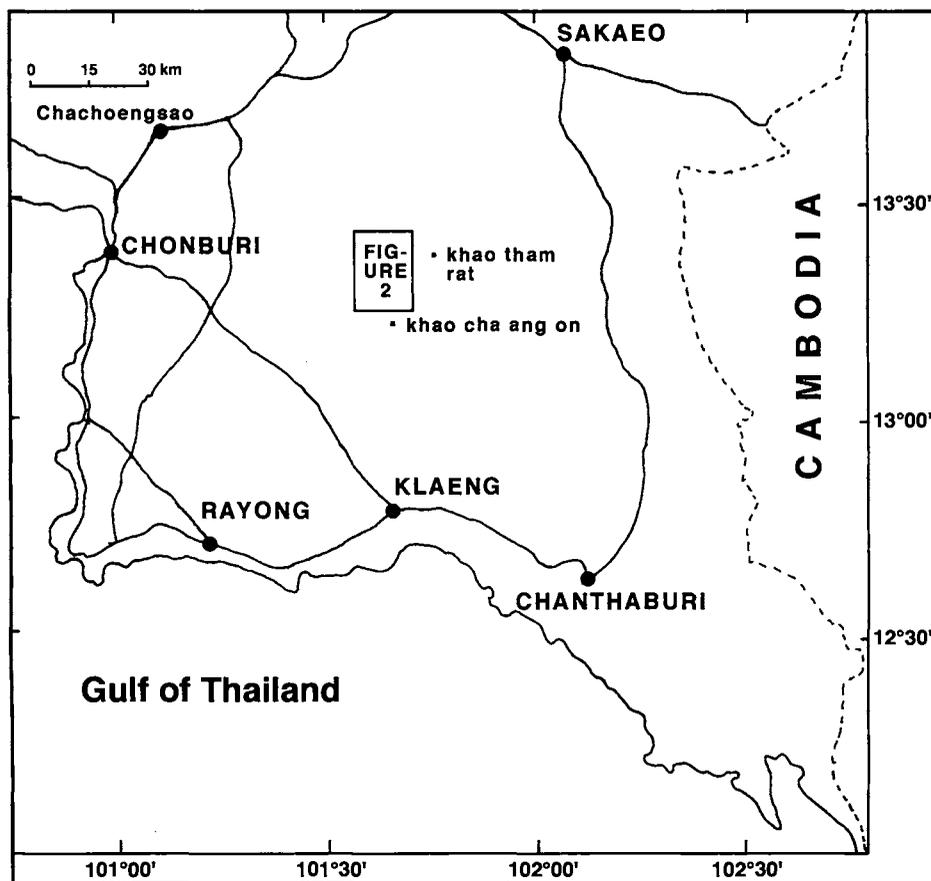
## THE FOSSILS

The fossils reported in this paper are those found in the limestone. They consist of pseudo-algae, algae, calcispheres, foraminifers, corals,

bryozoans, brachiopods, gastropods, ostracods and crinoids. Localities 1 to 7 (see Fig. 2) belong to the western series of Carboniferous exposures; they are moderately rich in fossils. Locality 8 is the single site of the eastern series of Carboniferous outcrops which has been visited. It is prominently rich in diverse fossils including several types of corals (Tabulata, solitary and fasciculate Rugosa, Heterocorallia).

**Locality 1 or the northern foot of Khao Kradat** (13°22'N, 101°36'E): Khao Kradat is divided into two hills which have their own names in the new topographical map on the scale 1:50.000: Khao Phai to the west and Khao Yoeng to the east. Khao Phai has not yielded fossils so far. Locality 1 is at the northwestern foot of Khao Yoeng. That locality has already been mentioned in a previous paper (Fontaine *et al.*, 1996); it has yielded foraminifers (*Endothyra*, *Eostaffella*, *Millerella*, and probably *Schubertella*), algae (*Windsoporella?*), pseudo-algae (*Ungdarella*). These fossils are associated with bryozoans, brachiopods, gastropods, ostracods and crinoids. They indicate a Bashkirian age.

**Locality 2 or the southern slope of Khao Kradat = Khao Yoeng** (13°21'30"N, 101°36'10"E):



**Figure 1.** Location of the Khao Tham Rat and Khao Cha-ang On areas and the area found in Figure 2.

The limestone is a grainstone rich in crinoids debris and very poor in other fossils.

**Locality 3 or a limestone hill south of Ban Thammarat Nai** (13°19'10"N, 101°36'55"E): The limestone is a wackestone containing rare foraminifers, some bryozoans, brachiopods and crinoids. The foraminifers consist of: *Earlandia minor* (Rausser, 1948), *Endothyra* ex gr. *similis* Rausser & Reitlinger 1936, *Endothyra?* sp., *Tetrataxis media* Vissarionova 1948 and *Koskinobigenerina prisca* (Lipina, 1948). They

indicate an Early Carboniferous age, Late Visean to Serpukhovian.

**Locality 4 or small hills west of Khao Phrik** (13°18'50"N, 101°37'E): The limestone is poor in fossils with the exception of crinoids. It contains very rare small solitary Rugosa.

**Locality 5 situated at the northwestern end of Khao Yai** (13°18'10"N, 101°37'50"E): The first studied samples from that locality were loose blocks strewn over the ground of a cultivated field. They were made of limestone rich in quartz sand and

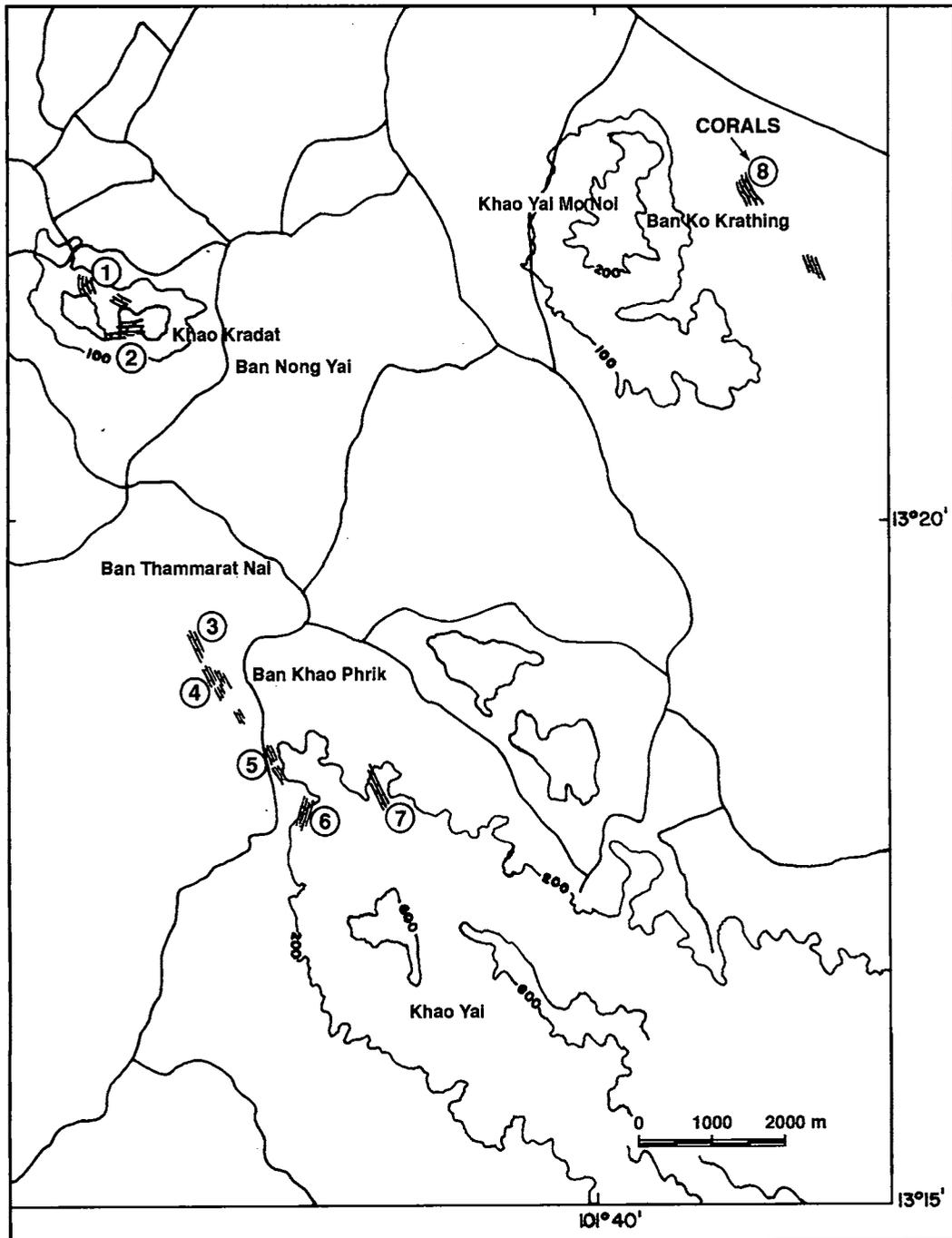


Figure 2. Localities (1–7) of the western series of Carboniferous exposure.

very poor in fossils with the exception of crinoids (Fontaine and Salyapongse, 1997). The hill was difficult of access at that time. During a new visit of that locality, it has been possible to collect samples from the hill itself. The limestone is dark gray and displays rare scattered macrofossils: moderately large gastropods, a few fragments of solitary Rugosa with dissepiments, shell fragments (brachiopods and bivalves), rare palechinid spines, crinoids. In thin sections, limestone is commonly a wackestone, occasionally a packstone. It is slightly recrystallized. It contains very rare foraminifers, not well preserved, consisting of *Earlandia minor* (Rauser, 1948), *Endothyra* sp. and *Tetrataxis* sp. A specimen of *Hexaphyllia*, 0.7 mm in diameter, has been noticed in a thin section (T5565). The limestone is not older than the Late Tournaisian because of the presence of *Tetrataxis*, and probably Late Visean-Serpukhovian in age because of the presence of *Hexaphyllia*.

**Locality 6 at Khao Yai south of locality 5** (13°17'45"N, 101°37'45"E): The limestone contains a few macrofossils: scattered brachiopods and common crinoids (Fontaine and Salyapongse, 1997). Foraminifers are locally in abundance and consist of: *Endothyra*, *Inflatoendothyra*, *Tetrataxis*, *Mediocris*?, *Chomatomediocris*, *Globispiroplectamina*. These fossils indicate a Visean age. The limestones of localities 5 and 6 belong to the same limestone unit which is exposed discontinuously over a distance of one kilometer and appears to reach 100 m in thickness.

**Locality 7 at the northeastern side of Khao Yai** (13°18'05"N, 101°38'10"E): Limestone contains calcispheres (*Pachysphaerina*?), algae (*Coeloporella delicata* Berchenko 1981), foraminifers which are locally in abundance (*Endothyra*, *Eoforschia*?, *Globispiroplectamina mellina* Malakhova 1956), bryozoans (Fenestellidae) and common crinoids. The foraminifers indicate a Visean age.

**Locality 8 east of Khao Yai Mo Noi** (13°22'30"N, 101°41'15"E): This limestone is rich in corals with rare Tabulata, a few solitary Rugosa (*Kueichouphyllum*?), large fasciculate Rugosa (*Siphonodendron* and *Solenodendron*) and abundant Heterocorallia (*Hexaphyllia*); see Fontaine and Salyapongse 1997. The corals are associated with calcispheres (*Pachysphaerina pachysphaerica* Pronina 1963, *Diplosphaerina inaequalis* Derville 1931), foraminifers, bryozoans, brachiopods, gastropods, ostracods, crinoids and trilobites. The foraminifers consist of: *Earlandia minor* (Rauser, 1948), *Earlandia vulgaris* (Rauser and Reitlinger, 1937), *Pseudoammodiscus volgensis* (Rauser, 1948), *Forschiella prisca* Mikhailov 1935, *Omphalotis* sp., *Endothyra* ex gr. *similis* Rauser & Reitlinger 1937, *Endothyra* ex gr. *bowmani* Phillips 1846 emend.

Brady 1876 emend. Cinz 1965, *Endothyranopsis crassa* (Brady 1876), *Koskinobigenenerina prisca* (Lipina 1948), *Mediocris medicris* (Vissarionova 1948), *Endostaffella* sp., *Endostaffella parva* (Moeller 1879), *Archaediscus* sp., *Archaediscus* ex gr. *convexus* Grozdilova & Lebedeva 1953, *Consobrinella* sp., *Tetrataxis acuta* Durkina 1959, bilamellar Palaeotextulariidae (*Palaeotextularia* or *Cribrostomum*?). These fossils indicate a Late Visean-Serpukhovian age.

## AGE

Because of the common presence of *Tetrataxis*, all the limestone outcrops cannot be older than the top of the Tournaisian (Tn3c). The youngest age has been obtained at Khao Kradat (Locality 1); it is Bashkirian. Fossils of localities 3 and 8 indicate clearly a Late Visean-Serpukhovian age. Other localities belong to the Visean-Serpukhovian interval. The rest have yielded poor faunas and cannot be dated with precision. These results might suggest different ages from Late Tournaisian to Bashkirian. Field study and the microfacies of the limestone are not favourable for such a hypothesis. All the limestone exposures display similar facies. They seem to belong to a Late Visean-Serpukhovian interval and only locally to the Bashkirian. Their differences appear to be due to a small variation in environmental conditions.

## CONCLUSION

Lower Carboniferous limestones are moderately exposed east of Chonburi in east Thailand. They were practically unknown in the past. They eventually raise a problem: what is the relationship of these limestones with younger sediments, especially with Permian sediments? In the past, red beds could be considered belonging to the Middle-Upper Carboniferous. The recent discovery of diverse rocks in the conglomerates of the red beds, with pebbles consisting of volcanic rocks which belong apparently to the Permian-Triassic volcanics, does not allow anymore to accept easily a Carboniferous age. The red beds appear to belong to the Mesozoic. An unconformity above the Carboniferous is possible, but cannot be assumed because of a lack of observation in the field due to a large cover of Mesozoic and Quaternary sediments.

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